71
8145 wc

PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : H01F 27/24	A1	(11) Internati nal Publication Number: **WO 98/34242** (43) International Publication Date: 6 August 1998 (06.08.98)

(21) International Application Number: PCT/SE98/00158

(22) International Filing Date: 2 February 1998 (02.02.98)

(30) Priority Data:

9700343-8	3 February 1997 (03.02.97)	SE
9704417-6	28 November 1997 (28.11.97)	SE

(71) Applicant *(for all designated States except US)*: ASEA BROWN BOVERI AB [SE/SE]; S-721 83 Västerås (SE).

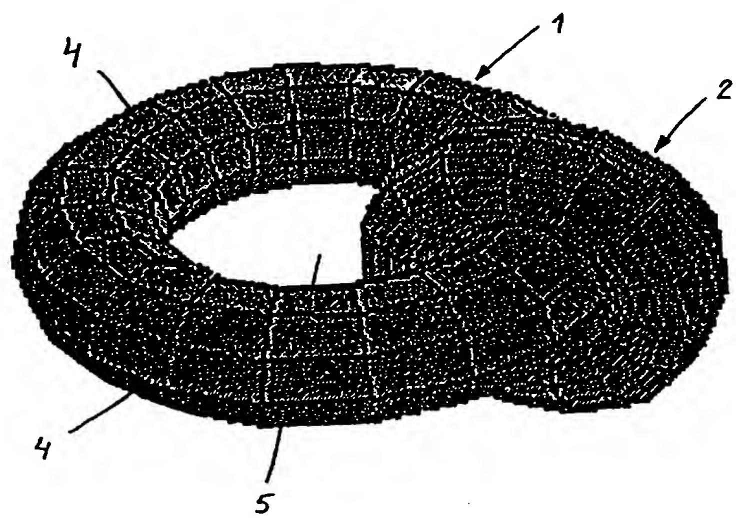
(72) Inventor; and
(75) Inventor/Applicant *(for US only)*: LEIJON, Mats [SE/SE]; Hyvlargatan 5, S-723 35 Västerås (SE).

(74) Agent: JOHANSSON WEBJÖRN, Ingmari; L. A. Groth & Co. KB, P.O. Box 6107, S-102 32 Stockholm (SE).

(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, CZ (Utility model), DE, DE (Utility model), DK, DK (Utility model), EE, ES, FI, FI (Utility model), GB, GE, GH, GM, GW, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).

Published
With international search report.
Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

(54) Title: A TRANSFORMER/REACTOR AND A METHOD FOR MANUFACTURING A TRANSFORMER/REACTOR



(57) Abstract

The present invention relates to a transformer or a reactor and a method of manufacturing a transformer/reactor. The transformer/reactor c mprises a core and at least one winding, in which the core (1; 11; 21; 31) consists of at least two segments (4; 14; 24, 25; 33, 34, 36, 37), and the winding is fl xibl and comprises an electrically conducting core (7) surrounded by an inner semic nducting layer (8), an insulating layer (9) surrounding the inner semiconducting layer and consisting of s lid material, and an outer semiconducting layer (10) surrounding the insulating layer, said layers adhering to each other.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania
AM	Armenia
AT	Austria
AU	Australia
AZ	Azerbaijan
BA	Bosnia and Herzegovina
BB	Barbados
BE	Belgium
BF	Burkina Faso
BG	Bulgaria
BJ	Benin
BR	Brazil
BY	Belarus
CA	Canada
CF	Central African Republic
CG	Congo
CH	Switzerland
CI	Côte d'Ivoire
CM	Cameroon
CN	China
CU	Cuba
CZ	Czech Republic
DE	Germany
DK	Denmark
EE	Estonia
ES	Spain
FI	Finland
FR	France
GA	Gabon
GB	United Kingdom
GE	Georgia
GH	Ghana
GN	Guinea
GR	Greece
HU	Hungary
IE	Ireland
IL	Israel
IS	Iceland
IT	Italy
JP	Japan
KE	Kenya
KG	Kyrgyzstan
KP	Democratic People's Republic of Korea
KR	Republic of Korea
KZ	Kazakstan
LC	Saint Lucia
LI	Liechtenstein
LK	Sri Lanka
LR	Liberia
LS	Lesotho
LT	Lithuania
LU	Luxembourg
LV	Latvia
MC	Monaco
MD	Republic of Moldova
MG	Madagascar
MK	The former Yugoslav Republic of Macedonia
ML	Mali
MN	Mongolia
MR	Mauritania
MW	Malawi
MX	Mexico
NE	Niger
NL	Netherlands
NO	Norway
NZ	New Zealand
PL	Poland
PT	Portugal
RO	Romania
RU	Russian Federation
SD	Sudan
SE	Sweden
SG	Singapore
SI	Slovenia
SK	Slovakia
SN	Senegal
SZ	Swaziland
TD	Chad
TG	Togo
TJ	Tajikistan
TM	Turkmenistan
TR	Turkey
TT	Trinidad and Tobago
UA	Ukraine
UG	Uganda
US	United States of America
UZ	Uzbekistan
VN	Viet Nam
YU	Yugoslavia
ZW	Zimbabwe

A transformer/reactor and a method for manufacturing a transformer/reactor

The present invention relates to a transformer/reactor comprising a core and at least one winding.

The present invention also relates to a method for use in the manufacturing of a corresponding transformer/reactor.

Transformers/reactors are available in all power ranges from a few W up to the 1000 MW range. The term "power transformer/reactor" generally refers to transformers/reactors having a rated output from a few hundred kW up to over 1000 MW and a rated voltage of from 3-4 kV up to extremely high transmission voltages.

A conventional power transformer comprises a transformer core, hereinafter called core, of laminated oriented sheet metal, usually ferrosilicon. The core consists of a number of core legs joined by a yoke. A number of windings are placed around the core legs, generally termed primary, secondary and regulating windings. In the case of power transformers, these windings are almost always arranged concentrically and distributed along the core legs. The transformer core has a rectangular "window" through which the windings pass. This rectangular window is primarily a result of the production technique used when the core is laminated.
The use of transformer cores of varying shape is known through DE 40414, US 2 446 999, GB 2 025 150, US 3 792 399, US 4 229 721, for instance. Some of these documents also discloses cores made up of segments. However, none of these documents pertain to high voltage power transformers, and they would not be applicable to such transformers due to the present technique of oil-cooling, discussed below.

Conventional power transformers at the lower end of the above-mentioned power range are sometimes provided with air cooling in order to remove the unavoidable natural losses in the form of heat. However, most conventional power transformers are oil-cooled, generally by means of pressurized oil cooling. This applies particularly to high-power transformers. Oil-cooled transformers have a number of well known drawbacks. They are, for instance, large, cumbersome and heavy, thus entailing in particular considerable transport problems, as well as the demands being extensive with regard to safety and peripheral equipment.

However, it has been proved possible to replace oil-cooled power transformers, to a great extent, with dry transformers of a new type. This new dry transformer is provided with a winding achieved by high-voltage cable, i.e. a high-voltage insulated electric conductor. Dry transformers can thus be used at considerably higher power rates than has previously been possible. The expressions "dry transformer" and "dry reactor" thus apply to a transformer/reactor which is not oil-cooled, but preferably air-cooled.

With regard to reactors (inductors), these comprise a core which mostly is provided with only one winding. In other respects, what has been stated above concerning transformers is substantially relevant also to reactors. It should be particularly noted that also large reactors are oil-cooled.

The object of the present invention is to provide a transformer or a reactor enabling some of the drawbacks inherent in the conventionally designed power transformers/reactors described here, to be eliminated and also to provide a method for use in manufacturing such a transformer/reactor.

The objects are achieved by means of a transformer/reactor having the features defined in claim 1, and by means of a

method for manufacturing such a transformer/reactor in accordance with the features defined in claim 25.

According to a first feature in claim 1, the core consists of at least two segments. The corresponding method includes the feature of manufacturing a core including at least two segments. The expression "segment" or "segmented core" means that the core of the transformer/reactor is built from substantially identical segments or parts joined together side by side to form the core.

Many advantages are gained with a core built from segments. First of all, even relatively large cores can be made substantially annular in shape which offers significant advantages which will be explained below.

Secondly, simpler winding of the core is possible since each segment can be wound separately.

A third advantage of segmented cores is that parts of the core can be dismantled or assembled at any time during manufacture.

Advantages are also obtained from the production point of view since the core can be built in the form of modules, each comprising one or more segments. This also offers considerable advantages with regard to transport since the core can be transported in segments and then assembled on the site where it is to be used. If necessary, the winding can also be wound on site.

According to a further feature in claim 1, the winding is flexible and comprises an electrically conducting core surrounded by an inner semiconducting layer, an insulating layer surrounding the inner semiconducting layer and consisting of solid material, and an outer semiconducting layer surrounding the insulating layer, said layers adhering to

each other. According to a further feature of the method, said method comprises the step of installing a winding onto the core which winding is defined in correspondence with claim 1.

Thus, the windings in a transformer/reactor according to the invention, are preferably of a type corresponding to cables having solid, extruded insulation, of a type now used for power distribution, such as XLPE-cables or cables with EPR-insulation. Such a cable comprises an inner conductor composed of one or more strand parts, an inner semiconducting layer surrounding the conductor, a solid insulating layer surrounding this and an outer semiconducting layer surrounding the insulating layer. Such cables are flexible, which is an important property in this context since the technology for the device according to the invention is based primarily on winding systems in which the winding is formed from cable which is bent (or curved) during assembly. The flexibility of a XLPE-cable normally corresponds to a radius of curvature of approximately 20 cm for a cable with a diameter of 30 mm, and a radius of curvature of approximately 65 cm for a cable with a diameter of 80 mm. In the present application the term "flexible" is used to indicate that the winding is flexible down to a radius of curvature in the order of four times the cable diameter, preferably eight to twelve times the cable diameter.

The winding should be constructed to retain its properties even when it is bent and when it is subjected to thermal stress during operation. It is vital that the layers retain their adhesion to each other in this context. The material properties of the layers are decisive here, particularly their elasticity and relative coefficients of thermal expansion. In a XLPE-cable, for instance, the insulating layer consists of cross-linked, low-density polyethylene, and the semiconducting layers consist of polyethylene with soot and metal particles mixed in. Changes in volume as a result of

temperature fluctuations are completely absorbed as changes in radius in the cable and, thanks to the comparatively slight difference between the coefficients of thermal expansion in the layers in relation to the elasticity of these materials, the radial expansion can take place without the adhesion between the layers being lost.

The material combinations stated above should be considered only as examples. Other combinations fulfilling the conditions specified and also the condition of being semiconducting, i.e. having resistivity within the range of 10^{-1}-10^{6} ohm-cm, e.g. 1-500 ohm-cm, or 10-200 ohm-cm, naturally also fall within the scope of the invention.

The insulating layer may consist, for example, of a solid thermoplastic material such as low-density polyethylene (LDPE), high-density polyethylene (HDPE), polypropylene (PP), polybutylene (PB), polymethyl pentene ("TPX"), cross-linked materials such as cross-linked polyethylene (XLPE), or rubber such as ethylene propylene rubber (EPR) or silicon rubber.

The inner and outer semiconducting layers may be of the same basic material but with particles of conducting material such as soot or metal powder mixed in.

The mechanical properties of these materials, particularly their coefficients of thermal expansion, are affected relatively little by whether soot or metal powder is mixed in or not - at least in the proportions required to achieve the conductivity necessary according to the invention. The insulating layer and the semiconducting layers thus have substantially the same coefficients of thermal expansion.

Ethylene-vinyl-acetate copolymers/nitrile rubber (EVA/NBR), butyl graft polyethylene, ethylene-butyl-acrylate copolymers

(EBA) and ethylene-ethyl-acrylate copolymers (EEA) may also constitute suitable polymers for the semiconducting layers.

Even when different types of material are used as base in the various layers, it is desirable for their coefficients of thermal expansion to be substantially the same. This is the case with the combination of the materials listed above.

The materials listed above have relatively good elasticity, with an E-modulus of E<500 MPa, preferably <200 MPa. The elasticity is sufficient for any minor differences between the coefficients of thermal expansion for the materials in the layers to be absorbed in the radial direction of the elasticity so that no cracks appear, or any other damage, and so that the layers are not released from each other. The material in the layers is elastic, and the adhesion between the layers is at least of the same magnitude as in the weakest of the materials.

The conductivity of the two semiconducting layers is sufficient to substantially equalize the potential along each layer. The conductivity of the outer semiconducting layer is sufficiently high to enclose the electrical field within the cable, but sufficiently low not to give rise to significant losses due to currents induced in the longitudinal direction of the layer.

Thus, each of the two semiconducting layers essentially constitutes one equipotential surface, and these layers will substantially enclose the electrical field between them.

There is, of course, nothing to prevent one or more additional semiconducting layers being arranged in the insulating layer.

Other characteristics and advantages will become apparent from the remaining dependent claims.

In addition to the above mentioned advantages obtained with a winding consisting of a cable, less problems with magnetic stray fields are encountered with the use of cable. This has the advantage that a toroidal core can be used even in high-voltage transformers, provided that the problem of arranging a sufficiently large core is solved and this is done according to the invention by using a segmented core. The important advantage follows that technology can be used which is previously known only from the low-voltage range and field of electronics.

According to a particularly advantageous feature, it is stated that the winding consists of high-voltage cable.

As another feature it is stated that the high-voltage cable preferably has a diameter within the interval 20-250 mm and a conductor area within the interval 80-3000 mm^2.

According to a particularly advantageous characteristic, the core is substantially annular. This design has the advantage of providing a shorter magnetic path than a rectangular core, and better flow distribution in the core. The advantages of an annular core with a shorter magnetic path than a conventional core include it requiring less material, it will be less heavy and less expensive and result in less power losses and is therefore more efficient.

According to another particularly favourable characteristic, the core has a substantially toroidal shape. In a toroidal core the coil can be distributed uniformly around the entire core, thereby reducing the problems of undesired magnetic fields. A high degree of symmetry is also favourable since the magnetic field diminishes more quickly with the distance.

According to one embodiment the core of the transformer/reactor has a window, which is substantially circular in shape and the annular shape of the core is circular. Alternatively the core may comprise a window which is substantially elliptical and the annular shape of the core is elliptical. The core may also be rectangular.

According to an advantageous embodiment the core is composed of two segments. In many cases this is naturally the simplest alternative, which per se constitutes an advantage.

According to another favourable embodiment the core is composed of four segments, two straight segments and two segments shaped as ring halves, the two segments shaped as ring halves being joined together via the two straight segments. This embodiment, as also the elliptical embodiment, has the advantage that it can be used even in cramped spaces.

That each segment comprises a plurality of plates and that the core is constructed as a laminated core are also stated to be advantageous features.

According to further advantageous features, the plates may consist of magnetically oriented steel and the number of segments is sufficiently large for the magnetic orientation direction not to be lost. Alternatively, the plates may consist of amorphous steel.

According to one embodiment, adjacent segments are held together by one segment having at least one protruding plate which is fitted into a corresponding gap, between plates, arranged in the corresponding side of the nearest adjacent segment, thereby forming an overlap joint. This results in the advantage that no special attachment means are required to keep the segments forming the core together. Alterna-

tively, or by way of supplement, however, the transformer/reactor may include attachment means.

According to yet another advantageous feature the segmented core contains internal ducts which may be used for a coolant. According to a particular embodiment of the cooling ducts the core segments can be connected thereby.

Finally, the method according to the present invention is characterized by the advantageous feature that the windings of the core are wound onto the segment before the segment is assembled to form the core.

The invention is preferably intended for single phase transformers.

As a summary, it should be stressed that, through the combination of a winding as defined in claim 1 and a segmented core, it is made possible by the present invention to provide dry transformers/reactors for high voltages, with large cores of a substantially annular shape, and preferably toroidal shape.

For a better understanding of the invention, four embodiments will now be described in detail, by way of example, with reference to the accompanying drawings in which:

Figure 1 shows a basic diagram in the form of a schematic view in perspective of a first embodiment of the invention,

Figure 2 shows a schematic view of a second embodiment of the invention,

Figure 3 shows a schematic view of a third embodiment of the invention,

Figure 4 shows a schematic view of a fourth embodiment of the invention,

Figure 5 shows a section through a segment of a core according to the present invention, and

Figure 6 shows a cross-sectional view of a high-voltage cable.

A basic diagram of the present invention, also constituting a first embodiment, is shown schematically in Figure 1. The figure illustrates a transformer core 1, which could equally well be a reactor core, provided with a winding 2 passing through a substantially circular window 5. The core is built from a relatively large number of segments 4, for which only one reference number is being used. The segments are preferably identical since this is an advantage from the manufacturing point of view, but could be shaped with some differences if suitable. The figure shows eighteen segments, each segment consisting of a number of plates 3 which have been stacked one on top of the other in a known manner. An example of how these plates can be stacked on top of each other is shown in Figure 5, illustrating a section through a core segment. The plates are normally glued together. By stacking the plates on top of each other a so called laminated core is obtained. Different joining methods may be used, of which only one possible method is being illustrated in Figure 5. Another possible method is known as step lap, for instance.

The individual plates illustrated in the embodiment in Figure 1 have a shape corresponding to a parallel trapezium. This means that the "annular" shape of the core is in fact a polygon. However, with a relatively large number of segments, as in this case, an annular shape, or toroidal as is the case with the cross section of the core, is approximated with a polygonal shape.

It should be emphasized that the terms "annular, circular window and toroidal", which comprises a circular cross section, and all of which refer to the core, these terms

refer in this context not only to a geometrically perfect ring, torus or circle, but should also be considered as including the approximate equivalents to these geometric figures due to the fact that the core, because of the segments, may have a through-section both in transverse and longitudinal direction that is in fact a polygon.

Figure 2 illustrates a second embodiment of the invention in the form of a core 11 with segments 14, seen from above. According to the embodiment in Figure 2, the segments have a shape similar to a pie piece with a truncated tip so that they may be combined to an approximate ring, preferably with a toroidal shape. Each plate 3 in Figure 5 is thus cut to fit the pie piece shape shown in Figure 2. In this case the core 11 is composed of eight segments 14. The segments in this core are built from plates of magnetically oriented steel, as illustrated by arrows in the Figure. When magnetically oriented steel is used it is important that the number of segments is sufficient for the magnetic direction of orientation not to be lost. Here too, the core has a circular window 15 through which the winding or windings are intended to pass.

A third embodiment of the core is shown in Figure 3. The segmented core 21 consists of only two segments in the form of two ring halves 23, 24 which have been combined to a core with a substantially circular window 25.

The fourth embodiment is illustrated in Figure 4, from which is seen that the core 31 preferably comprises four segments: two straight segments 36, 37 and two segments 33, 34 in the form of half rings. The two segments 33, 34 in the form of ring halves are connected via the two straight segments 36, 37. The core has a window 35.

The segments can be held together or combined in various ways to form the annular core. It is thus feasible to con-

figure the segments with some plates protruding outside the actual side of the segment, i.e. the side facing an adjacent segment, and which are inserted into corresponding gaps, between plates, arranged in the corresponding side of the nearest adjacent segment, and vice versa, so that plates in adjacent segments overlap. A joint is thus obtained between the plates in two adjacent segments, which is formed in an equivalent way to the example of joints formed inside a segment which is illustrated in Figure 5. Alternatively, special attachment means may be used, such as clamps, yokes, screws of the like.

One advantage of a segmented core is that it may include internal ducts for a coolant. These ducts may consist of interspaces 17, which have been provided between the plates during lamination. Alternatively, tubes for a coolant may be installed in the segments during lamination of the plates. Another alternative is to subsequently drill ducts through the segments. It would also be possible for the segments to be held together by the internal cooling ducts, in such a way that adjacent segments are being held together by at least one segment being provided with a cooling duct terminating in a protruding pipe end shaped to be fitted to a corresponding pipe end terminating the cooling duct in an adjacent segment.

Figure 6, finally, shows a section through a high-voltage cable 6 particularly suitable for use in the invention. The high-voltage cable 6 comprises a number of strands 7 made of copper (Cu), for instance, and having circular cross section. These strands are arranged in the middle of the high-voltage cable. Surrounding the strands 7 is a first semi-conducting layer 8. Surrounding this first semi-conducting layer 8 is an insulating layer 9, e.g. XLPE insulation. Surrounding the insulating layer 9 is a second semi-conducting layer 10 provided. The cable illustrated differs from conventional high-voltage cable in that the outer,

mechanically protective sheath and the metal screen that normally surround such cables are eliminated. Thus the concept "high-voltage cable" in the present application does not necessarily include the metallic screen or the sheath that normally surround such cables for power distribution.

The embodiments illustrated and described above shall be considered only as examples and the invention shall not be limited thereto, but can be varied within the scope of the inventive concept as defined in the appended claims. Thus, the window in the cores of three of the examples illustrated has been shown only with substantially circular form, but may of course also be elliptical or some other shape. Similarly, the annular shape of the core may be elliptical instead of circular. This may be preferable, for instance, when the available space is limited widthwise. Furthermore, there is naturally nothing to prevent a segmented core being made rectangular, with a rectangular window.

The number of segments may also vary greatly depending on many different considerations with regard to manufacturing technique, winding technique, transport distance, etc. The plates may also be made of steel other than magnetically oriented steel, e.g. amorphous steel.

Finally, it should be mentioned that the invention is naturally also applicable to a three-phase transformer/reactor by combining three cores constructed in accordance with the invention.

\- - - - -

CLAIMS

1. A transformer/reactor comprising a core and at least one winding, in which the core (1; 11; 21; 31) consists of at least two segments (4; 14; 24, 25; 33, 34, 36, 37), and the winding is flexible and comprises an electrically conducting core (7) surrounded by an inner semiconducting layer (8), an insulating layer (9) surrounding the inner semiconducting layer and consisting of solid material, and an outer semiconducting layer (10) surrounding the insulating layer, said layers adhering to each other.

2. A transformer/reactor as claimed in claim 1, characterized in that said layers (8, 9, 10) consist of materials having such elasticity and with such a relation between the coefficients of thermal expansion of the materials that the changes in volume in the layers caused by temperature fluctuations during operation can be absorbed by the elasticity of the materials, the layers thus retaining their adhesion to each other upon the temperature fluctuations that occur during operation.

3. A transformer/reactor as claimed in claim 2, characterized in that the materials in said layers (8, 9, 10) have high elasticity, preferably with an E-modulus less than 500 MPa, most preferably less than 200 MPa.

4. A transformer/reactor as claimed in claim 3, characterized in that the coefficients of thermal expansion for the materials in said layers (8, 9, 10) are of substantially the same magnitude.

5. A transformer/reactor as claimed in claim 4, characterized in that the adhesion between the layers (8, 9, 10) is of at least the same magnitude as in the weakest of the materials.

6. A transformer/reactor as claimed in claim 1 or claim 2, characterized in that each of the semiconducting layers (8, 10) essentially constitutes one equipotential surface.

7. A transformer/reactor as claimed in any of claims 1-6, characterized in that the windings of the stator (4) consist of high-voltage cable (6).

8. A transformer/reactor as claimed in claim 7, characterized in that the high-voltage cable (6) has a diameter within the interval 20-250 mm and a conductor area within the interval 80-3000 mm^2.

9. A transformer/reactor as claimed in any of the preceding claims, characterized in that the core (1; 11; 21) is substantially annular.

10. A transformer/reactor as claimed in claim 9, characterized in that the core (1; 11; 21) comprises a window (5; 15; 25) having substantially circular shape and that the annular shape of the core is circular.

11. A transformer/reactor as claimed in claim 9, characterized in that the core comprises a window which is substantially elliptical and that the annular shape of the core is elliptical.

12. A transformer/reactor as claimed in any of claims 1-8, characterized in that in that the core (31) comprises four segments, two straight segments (36, 37) and two segments (33, 34) shaped as ring halves, the two segments shaped as ring halves being joined together via the two straight segments.

13. A transformer/reactor as claimed in any of the preceding claims, characterized in that the core (1; 11; 21) has a substantially toroidal form.

14. A transformer/reactor as claimed in any of claims 1-8, characterized in that the core has a rectangular form.

15. A transformer/reactor as claimed in any of claims 1-11 or 13-14, characterized in that the core (21) consists of two segments (23, 24).

16. A transformer/reactor as claimed in any of the preceding claims, characterized in that each segment comprises a plurality of plates (3) and in that the core is constructed as a laminated core.

17. A transformer/reactor as claimed in claim 16, characterized in that the plates (3) consist of magnetically oriented steel.

18. A transformer/reactor as claimed in claim 17, characterized in that the number of segments is sufficiently large for the magnetic orientation direction not to be lost.

19. A transformer/reactor as claimed in claim 16, characterized in that the plates (3) consist of amorphous steel.

20. A transformer/reactor as claimed in any of claims 16-19, characterized in that the adjacent segments are held together by one segment having at least one protruding plate which is fitted into a corresponding gap between plates arranged in the corresponding side of the nearest adjacent segment, thereby forming an overlap joint.

21. A transformer/reactor as claimed in any of the preceding claims, characterized in that it comprises attachment devices, preferably clamps or screws in order to join the segments.

22. A transformer/reactor as claimed in any of the preceding claims, characterized in that the segmented core contains internal ducts (17) for a coolant.

23. A transformer/reactor as claimed in claim 22, characterized in that adjacent segments are held together by at least one segment being provided with a cooling duct (17) terminating in a protruding tube end designed to be fitted to a corresponding tube end terminating the cooling duct in an adjacent segment.

24. A transformer/reactor as claimed in any of the preceding claims, characterized in that the transformer is a dry transformer/reactor.

25. A method for use in the manufacturing of a transformer/reactor comprising a core and at least one winding, comprising the step of manufacturing a core including at least two segments which are joined to form said core, and comprising the step of installing a winding onto said core, said winding being flexible and composed of an electrically conducting core (7) surrounded by an inner semiconducting layer (8), an insulating layer (9) surrounding the inner semiconducting layer and consisting of solid material, and an outer semiconducting layer (10) surrounding the insulating layer, said layers adhering to each other.

26. A method as claimed in claim 25, characterized in that the windings of the core are wound onto the segment before the segment is assembled to form the core.

- - - - -

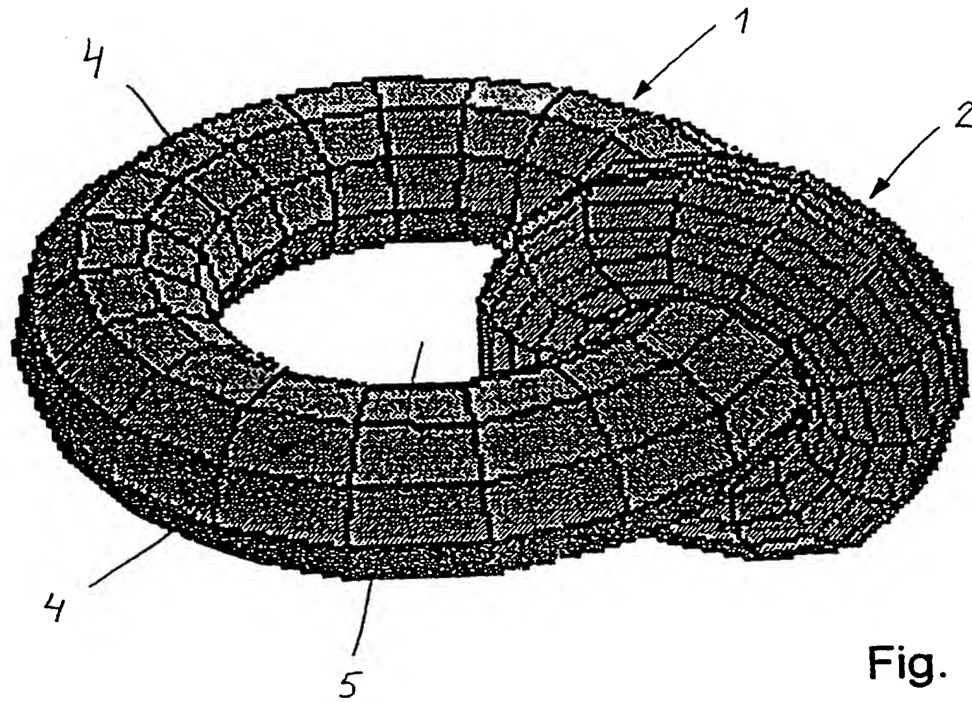


Fig. 1

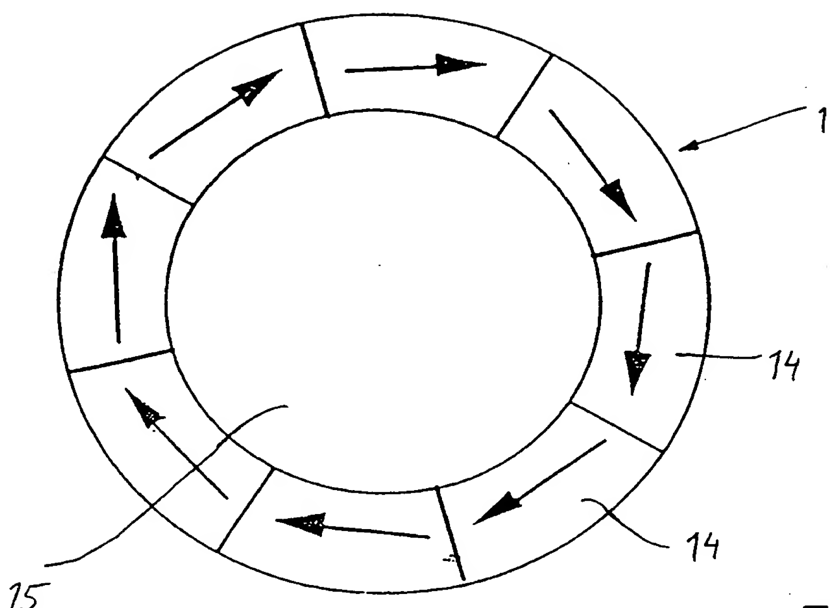


Fig. 2

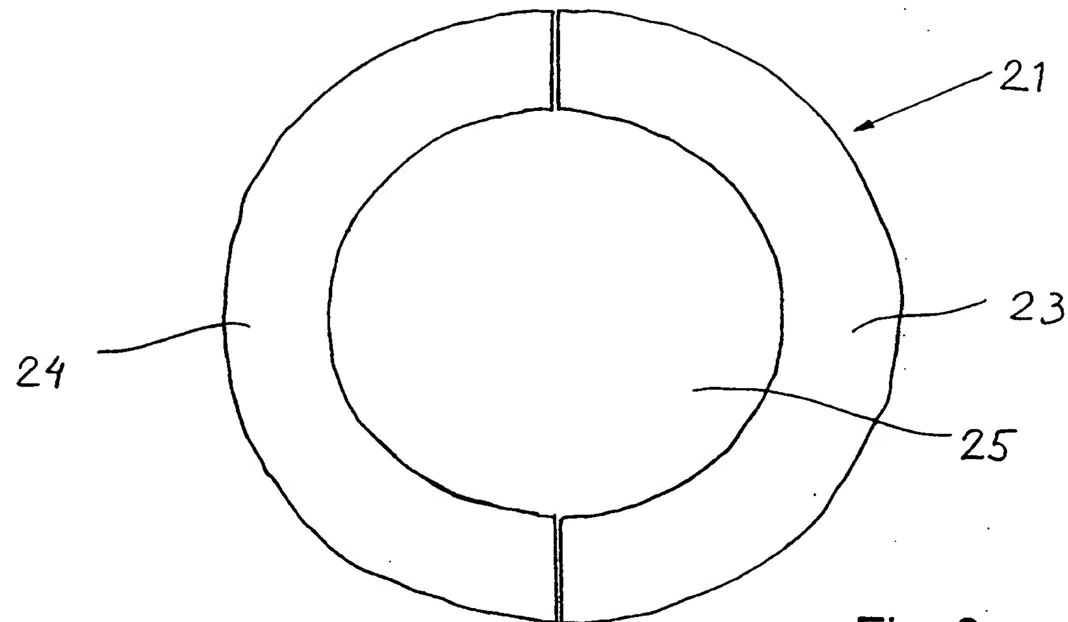


Fig. 3

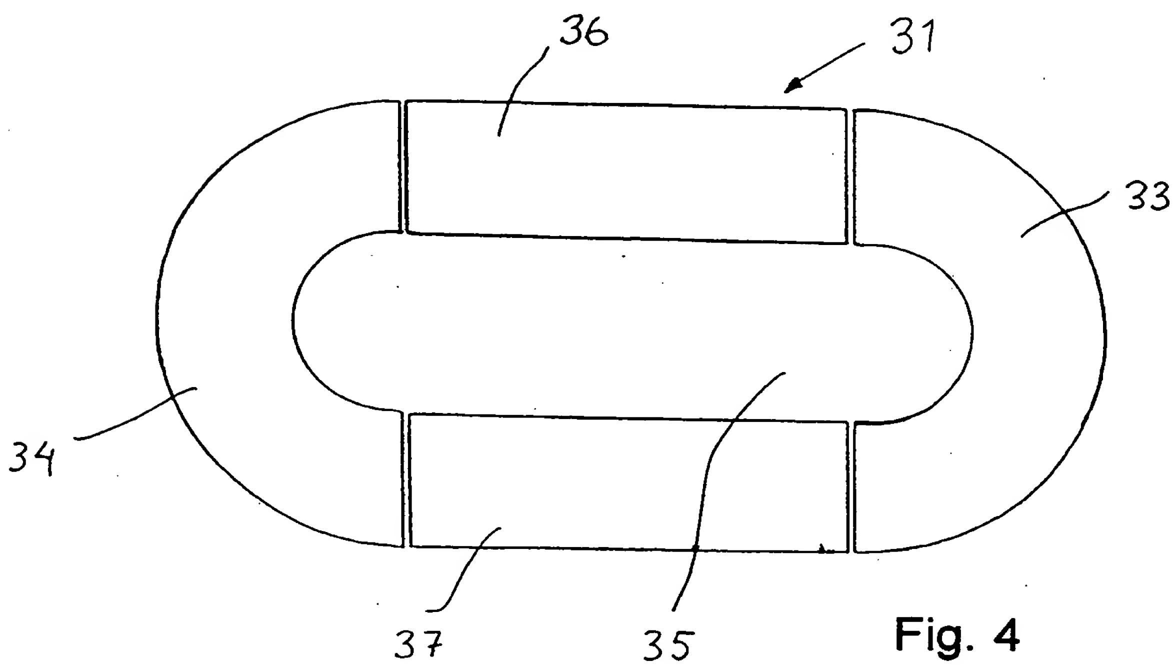


Fig. 4

THIS PAGE BLANK (USPTO)

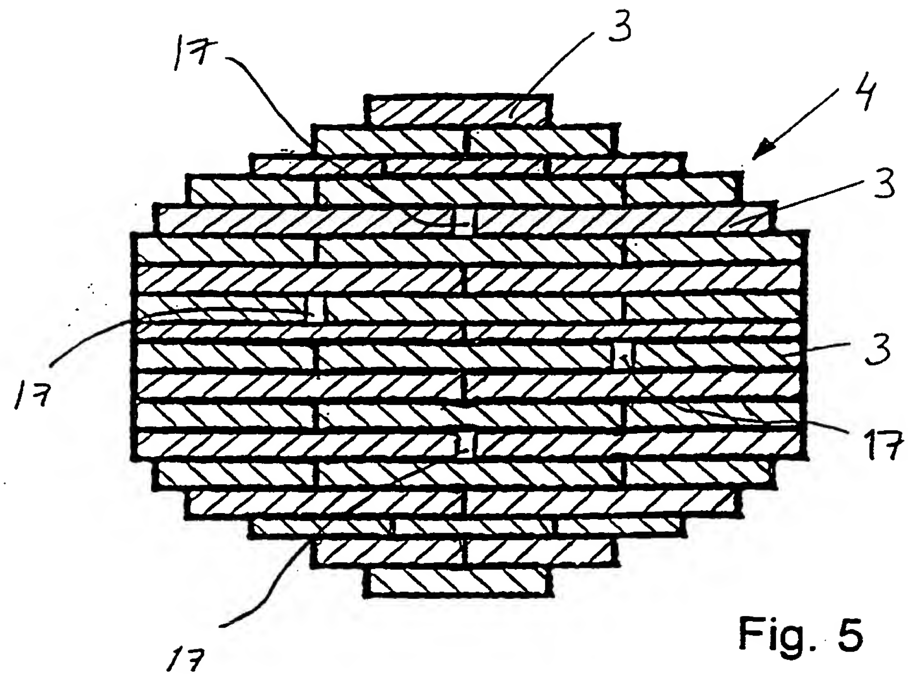


Fig. 5

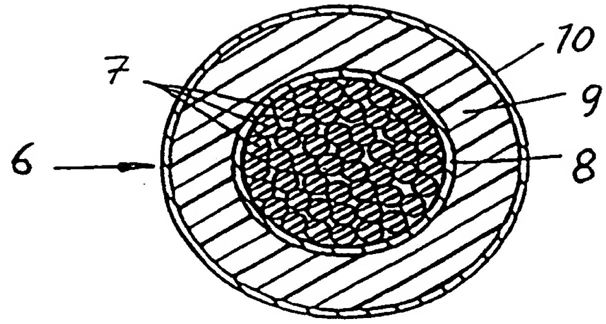


Fig. 6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 98/00158

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: H01F 27/24

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: H01F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EDOC, WPIL, JAPIO

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2446999 A (G.CAMILLI), 17 August 1948 (17.08.48), figures 2,3 --	1,25
A	US 5036165 A (RICHARD K. ELTON ET AL), 30 July 1991 (30.07.91), abstract -- --------	1,25

☐ Further documents are listed in the continuation of Box C.   ☒ See patent family annex.

* Special categories of cited documents:
- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" erlier document but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed
- "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- "X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- "Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
- "&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
11 June 1998	16 -06- 1998

Name and mailing address of the ISA/	Authorized officer
Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Magnus Westö Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT

Information on patent family members

29/04/98

International application No.
PCT/SE 98/00158

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2446999 A	17/08/48	NONE	
US 5036165 A	30/07/91	US 5066881 A	19/11/91
		US 5067046 A	19/11/91
		CA 1245270 A	22/11/88
		US 4853565 A	01/08/89